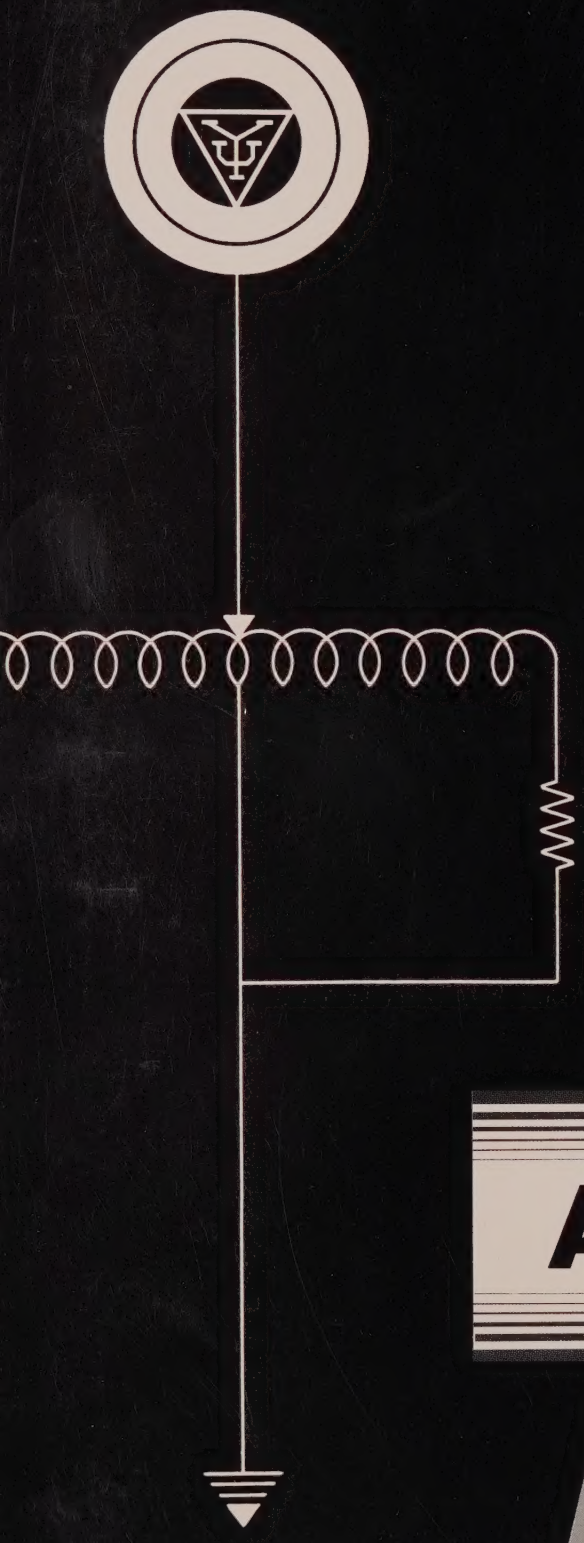
524A-3

524-3L



Electronic

INSTRUMENTS

PHASE METERS

DELAY LINES

AD-YU ELECTRONICS, INC.

249-259 TERHUNE AVE.,
PASSAIC, N. J., U.S.A.
PHONE: GR 2-5622
CABLE: ADYU PASSAIC

DIGITAL PHASE METER TYPE 524A3

±0.03 DEGREES ACCURACY
USEFUL FROM 20 CPS UP TO 500 KC

Fig. 1 — Type 524A3 Digital Phase Computer with a four-digit indicator.

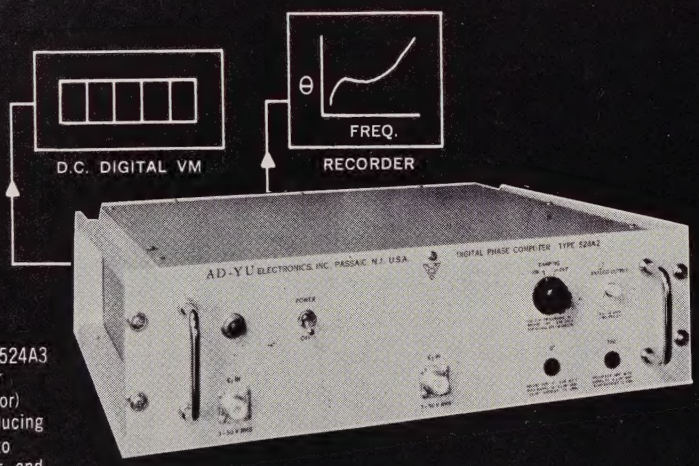


Fig. 2 — Type 524A3 Phase Computer (without indicator) capable of producing analog output to drive a recorder, and d.c. digital voltmeter.

FEATURES:

Phase angle in degrees directly represented in four digits.
Phase reading independent of the ratio of signal amplitude. No amplitude adjustment in both channels.
Analog (or digital) output available for external recorder or programmable systems.
No frequency adjustment over a wide range, from 20 cps to 500 kc.
No ambiguity or instability in the vicinity of 0° or 360°.
Relative accuracy ±0.03° plus error of digital indicator for symmetrical waveforms of any shape.

USES:

Plot phase vs. frequency curve of unknown network from 20 cps to 500 kc.
Plot envelope delay curve with RF sweep oscillator, amplitude modulated carrier frequency up to microwave.
Use as standard phase meter with 5-digit d.c. voltmeter as readout, accuracy ±0.03°.
Use as phase computer for system control.

AD-YU ELECTRONICS, INC.

NEW PASSAIC LABORATORY

249-259 Terhune Avenue, Passaic, N. J., U.S.A.
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OPERATING PRINCIPLE:

Digital Phase Meter Type 524A3 is the most advanced instrument for direct reading of phase angle in degrees between two alternating voltages. Fluctuation of signal amplitude or continuous variation of signal frequency does not affect the accuracy of phase reading. Phase difference as small as 0.1° can be read directly by a numeral of 1″ height, 0.01° possible with 5-digit d.c. voltmeter. The instrument is extremely stable for measuring a small fraction of 1° in the vicinity of 0° or 360° without self-triggering. Type 524A3 provides analog output for direct plotting of phase characteristic curve on recorder. The digital voltmeter can provide digital output for operating tape punches, electric typewriters and printers at a slightly higher cost. Symmetrical distortion cannot affect the accuracy of the instrument, since the circuit has no response to harmonics having zero degree or 180 degree phase difference. Other forms of distortion can be isolated by a pair of AD-YU Type A103 Filters or AD-YU Type 1034 Dual-Channel Synchronous Filter. Type 524A3 is especially suitable for phase measurement in production lines because phase reading is indicated directly in numerals and requires no amplitude adjustment, no frequency adjustment and no zeroing. Type 524A3 is also an ideal instrument for development laboratories, because it has excellent accuracy, small resolution, and a wide range of amplitude response and frequency response.

Fig. 3 shows a block diagram of the instrument. Each channel has three stages of cathode coupled limiters which amplify the signal and at the same time cut an identical amount from top and bottom of the input waveform. These stages are used for removal of phase error due to fluctuation of signal amplitude. For phase measurement of networks, amplifiers, physical phenomena, phase change is normally accomplished by variation of signal amplitude. Therefore, in order to plot phase characteristic curve automatically and to avoid the

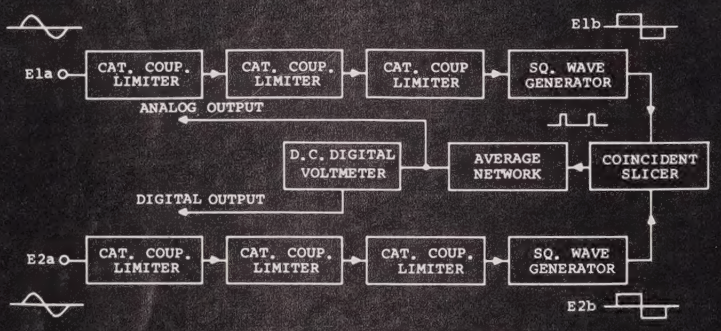
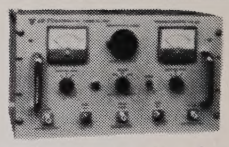


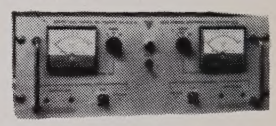
Fig. 3 — Block diagram of Type 524A3

tedious procedure of adjusting both the signal amplitudes, phase reading independent of signal amplitude is absolutely essential. The square wave from the cathode coupled limiters are being differentiated and transferred into positive and negative pulses. Only the positive pulses are used to trigger the subsequent stage. As a result, perfect symmetrical square wave for good accuracy is achieved and the distortion on the negative-going slope of the input signals will be disregarded. The coincident circuit produces an output current when the positive slope of the input signal of E2 channel intercepts the zero axis. This output current becomes zero again as soon as the positive slope of the input signal of E1 channel intercepts the zero axis. As a result, the indicator always reads the phase angle of E1 lags E2. In addition, the amplitude of the output pulse from the coincident circuit is carefully regulated by a reference zener diode to be constant regardless the amplitude and frequency of both signals. This enables the instrument to operate with swept frequency. The width of the output pulse from the coincident circuit changes instantaneously whenever phase angle between two input signals changes. This enables the instrument to produce rapid response to the variation of input phase angle. The output pulse from the coincident circuit enters the averaging network which produces an analog voltage directly proportional to the phase angle between the two input signals. This analog voltage is applied to a d.c. digital voltmeter for representing the phase angle in four digits or five digits. This analog voltage is adjusted to be −3.6 volts for 360 degrees, every 1 millivolt change for an increment of 0.1°. Further details on cathode-coupled limiters and coincident slicer are given in an article entitled "Coincident Slicer Measures Phase Directly," written by Dr. Y. P. Yu, President and Chief Engineer of AD-YU Electronics, Inc., published in Electronics, September 12, 1958.

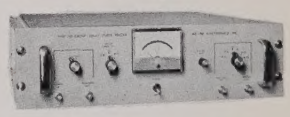
ALLIED EQUIPMENT



Frequency Converter, Type 306, can be used with a local oscillator to convert two RF signals (1 mc to 200 mc) to audio signal for phase measurement with Type 524A3. The specifications are: voltage amplification — 60 db; input impedance — 50 ohms direct, 2.5K with probe; maximum output — 40 volts rms.



Type 1034 Dual-Channel Synchronous Filter can be used with Type 524A3 Digital Phase Meter to plot phase vs. frequency curve with distorted signal. When Type 1034 is synchronized with an external sine wave signal, the output will be pure sine wave with its frequency equal to that of the sync signal. The phase angle between the two output signals are identical to that between the two input signals.



Type 701 Group Delay Curve Tracer is designed for operation with swept frequency from 250 cps to 600 kc and is intended for plotting delay distortion curves of audio equipment, telephone circuits, etc. Type 702 Group Delay Curve Tracer operates with swept frequency from 3 mc to 500 mc and is intended for plotting group delay curves of TV circuits, IF amplifiers, etc.

ACCESSORIES

Type A105 Impedance Converter is intended for matching the output of Type 524A3 Phase Computer to a low impedance recorder. Completely transistorized and contains its own power supply Input impedance — 500K, residual output — zero, voltage gain — 0.9 with maximum output of 4 volts. Price $168.00 each.

Matched pairs of pre-amplifiers are available for signal level below 300 millivolts. Completely transistorized. Size 2⅞″ x 1-7/16″ x 1½″ with batteries included. Type A102J has bandwidth from 1 cps to 1 mc and gain of 20 or 40 db with maximum output of 4 volts rms. Other types with different bandwidth and gain are available. Price, $59.00 and up.

Type A103 Variable Bandpass Filter has over 40 db attenuation for harmonics and noise; can be supplied in matched pairs. Center frequency continuously adjustable over 6 to 1 range, available from 50 cps to 500 kc. Price, $59.00 and up.

PHASE COMPUTER SPECIFICATIONS:

FREQUENCY RESPONSE:

Continuous coverage from 20 cps to 500 kc without adjustment.

ACCURACY:

Phase Computer only: The relative accuracy is ±0.03° and the absolute accuracy is ±0.06° from 20 cps to 40 kc. The error slowly increases up to ±0.06° relative and ±0.2° absolute at 100 kc. Above 100 kc, error increases 0.2° per 100 kc plus 0.1% of the reading per 100 kc. (See Note 1 and 2).
With a 4-Digit D.C. Voltmeter as indicator: The relative accuracy is ±0.1°, and the absolute accuracy is ±0.3° from 20 cps up to 40 kc. The error increases slowly up to ±0.2° relative and ±0.4° absolute at 100 kc. Above 100 kc, an additional error of 0.2° per 100 kc plus 0.1% of the reading per 100 kc. (See Note 1 and 2).

PHASE RANGE:

0 to 360.0 degrees, displayed in four digit (or five digits) without range switching.

PHASE INDICATION:

Digital readout with illuminated numerals in four places, see detailed specifications for digital indicator.

INPUT VOLTAGE:

The specification for accuracy is not affected by fluctuation of signal amplitudes in either one or both input channels within the range from 0.5 volt up to 50 volts rms, down to 0.03 volt with slightly more error. (See Note 3).

INPUT IMPEDANCE:

3 megohms shunted by 30 uuf on both channels.

INPUT SIGNAL RATIO:

Digital readout is completely independent of the ratio of signal amplitudes ranging from 1 to over 100.

INPUT POWER:

Phase Computer only — 60 watts, 50/60 cycles at 115 volts ±10%, 230 volts ±10% available on request at no extra charge.

DISTORTION OF INPUT SIGNAL:

The accuracy of the instrument is not affected by even harmonics which have zero degree or 180 degrees phase difference with the fundamental.
(See Note 4).

ANALOG OUTPUT SIGNALS:

Two d.c. potentials with their amplitudes equal and directly proportional to the unknown phase angle are provided for (a) connection to a d.c. digital voltmeter for direct reading of phase angle in four digits, and (b) for connection to an external recorder for plotting phase characteristic curve. Response time can be made less than 10/f milliseconds where f is the signal frequency in kc. Both analog outputs are zero in respect to chassis ground for zero phase angle, change linearly to negative 3.6 volts for 360°. One millivolt change for every 0.1° increment. Output impedance is approximately 200K for both outputs (100K possible on request). (For operation with recorder having low input impedance, use AD-YU Type A105 Impedance Converter.)

DIMENSIONS:

Phase Computer — front panel, 19″ x 5¼″ with standard rack mount slots; cabinet, 14″ deep. Weight 47 lbs.

NOTES:

(1) The term relative accuracy means the accuracy of difference in phase reading from one condition to another. For example, it may be interpreted as accuracy of (1) repeatability, (2) comparison of readings among unknown signals with respect to a given signal, (3) relative phase angle due to variation of signal characteristics, such as change of frequency, amplitude, or the characteristic of the network through which one (or both) input signal flows. The term absolute accuracy means the accuracy of the phase reading in comparison with a phase standard.
(2) In order to realize the accuracy of 0.1°, the harmonic contents of both input signals should be less than 0.17%; since sin 0.1° = 0.0017, thus the ratio of harmonic amplitude to fundamental amplitude should be less than 0.0017.
(3) For signal below 0.3 volt, a matched pair of AD-YU Type A102 Series Pre-Amplifiers with gain of 40 db or more can be used. For signal above 50 volts, a pair of AD-YU Type AT101 Attenuator Probes with 20 db attenuation can be used to increase the maximum limit up to 500 volts rms.
(4) Other forms of distortion and noise can be isolated by a pair of AD-YU Type A103 Continuously Adjustable Bandpass Filters, or AD-YU Type 1034 Dual-Channel Synchronous Filter.
(5) PRICE: Phase Computer only Type 524A3 (no digital voltmeter) — $999.00; complete with digital indicator Type 524A3R $2,449.00.

DIGITAL INDICATOR SPECIFICATIONS

ACCURACY:

±1 digit. +0.005% per °C.

READOUT:

1″ numeral, displayed in 4 digits.

COMMON MODE REJECTION:

Floating input provides 80 db rejection to common mode a.c. signals including hum, noise, and 60 cps pick-up, 50 cps available on request, essentially infinite to d.c. common mode signals.

SENSITIVITY:

1 millivolt d.c. per digit. 999.9 millivolts full scale.

INPUT IMPEDANCE:

1000 megohms at balance.

INPUT POWER:

50 watts at 115 volts 60 cps. 230 volts 50 cps available (extra cost).

AVERAGE BALANCE TIME:

Approx. 1 second.

DIMENSIONS:

Front panel, 19″ x 5¼″; cabinet 17″ x 5¼″ x 13″

SUGGESTED APPLICATIONS

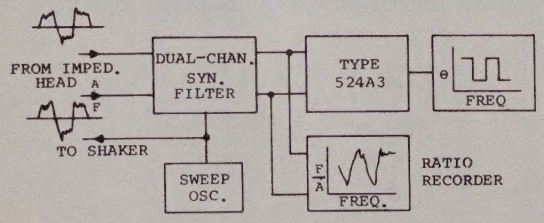


Fig. 4 – Plot phase vs. frequency curve with excessive distortions.

MEASURING PHASE WITH SIGNALS HAVING EXCESSIVE DISTORTION — FIG. 4

Signals from transducers, accelerometers, magnetic pickups, impedance heads, etc., often contain distortion and harmonics more than one-thousand percent. In order to measure phase or to plot phase vs. frequency curve, AD-YU Type 1034 Dual-Channel Synchronous Filter should be used for eliminating noise and harmonics before applying to Type 524A3 Digital Phase Meter. Fig. 4 shows the arrangement for plotting phase vs. frequency curve of signals F (force) and A (acceleration), also for plotting amplitude ratio curve of F/A. These curves will show the mechanical impedance of the object which is excited by a shaker operated by the sweep oscillator.

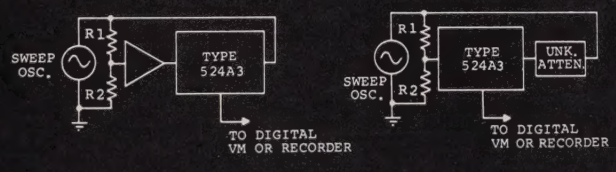


Fig. 5a (left) – Plot phase curve of high gain amplifier.
Fig. 5b (right) – Plot phase curve of attenuator.

PLOT PHASE VS. FREQUENCY CURVE WITH HIGH AMPLITUDE RATIO — FIG. 5

Type 524A3 Digital Phase Meter can be used to measure phase vs. frequency curve of high gain amplifiers, attenuators, etc., where the amplitude ratios of input and output are generally very high. In this case, a voltage divider with one resistor having small value (less than 100 ohms) should be used for amplitude equalization. In Fig. 5a, the values of R1 and R2 are (R1 + R2)/R2 ≃ gain of the amplifier and R1 < 100 ohms. Likewise, in Fig. 5b, R2 (R1 + R2) ≃ attenuation of the unknown network and R2 < 100 ohms.

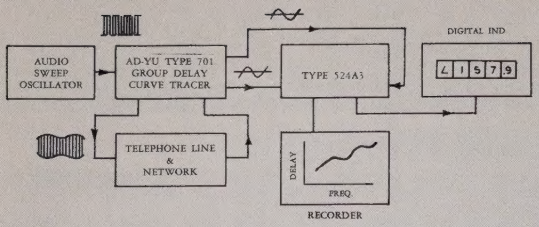


Fig. 6 – Plot delay distortion curve for telephone network.

PLOT DELAY DISTORTION CURVE — FIG. 6

Constant delay for all frequency components becomes important for faithful reproduction of input signals over long distance telephone lines. Delay distortion from 250 cps up to 500 kc can be measured or automatically plotted with the arrangement of Fig. 6. The modulated frequency of Type 701 Group Delay Curve Tracer should be lower than the second sub-harmonic of the sweep oscillator. For example, 100 cps is the highest recommended for the sweep signal starting from 250 cps. The signal supplied by the sweep oscillator is amplitude modulated by the local oscillator of Type 701 Group Delay Curve Tracer. The frequency of the local oscillator can be set at 40 or 80 cps, which corresponds to a total delay range of 25 or 12.5 milliseconds on the output recorder. The output signal from the unknown is converted to the local oscillator frequency by the detector of Type 701 Group Delay Curve Tracer. Type 524A3 Digital Phase Meter produces an analog output proportional to the phase difference between the output of the local oscillator and the envelope of the output signal from the unknown. Thus, the curve plotted on the recorder is the envelope delay curve of the unknown. Type 701 Group Delay Curve Tracer provides phase balance adjustment to cancel the phase shift of the modulator and detector. The digital indicator is used to read small delay difference in the critical region, 0.03 millisecond per digit with a 4-digit indicator.

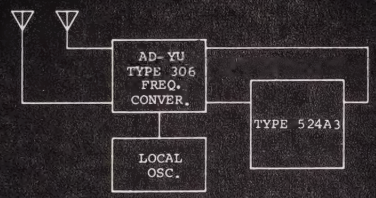


Fig. 7 – Measure phase between two antennas.

MEASURE PHASE AT RF FREQUENCIES — FIG. 7

Type 524A3 Digital Phase Meter can be used to measure phase angle from 1 mc up to 200 mc when used in conjunction with Type 306 Frequency Converter. Fig. 7 shows the use of Type 524A3 Digital Phase Meter to measure phase relations between the exciting currents of two antenna elements. The frequency of the local oscillator should be stable and set within 100 kc from the frequency range of the RF signals.

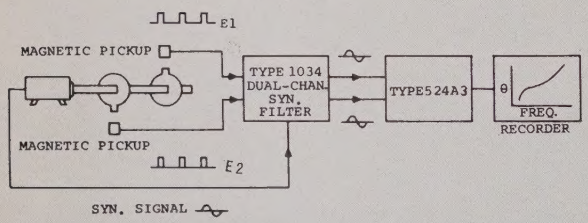


Fig. 8 – Phase measurement between pulses.

MEASURE PHASE BETWEEN SHORT PULSES — FIG. 8

Measurement of phase angle between short pulses is often required for precision measurement of torque, synchronization in color printing machines, etc. The arrangement is shown in Fig. 8. AD-YU Type 1034 Dual-Channel Synchronous Filter is used to select the fundamental component of the two short pulses, E1 and E2, from the magnetic pickups and isolate the harmonic components. When Type 1034 is synchronized with an external sine-wave signal, only the component having the same frequency as the synchronized signal is permitted to pass through to the output terminal. If the frequency of the synchronized signal is continuously swept, then the output signals will also follow to sweep at the same frequency and same rate. Thus, Type 524A3 will plot the phase characteristic curve between the fundamental component of the two pulses, E1 and E2, on a recorder, or present the phase directly in degrees digitally.

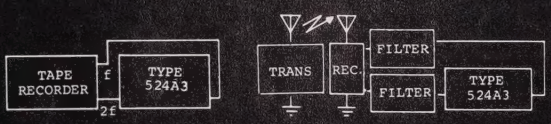
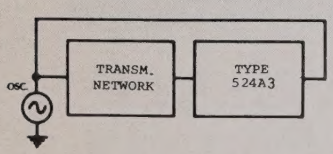


Fig. 9a (left) – Measure phase characteristics of tape recorder.
Fig. 9b (right) – Measure transition time between transmitter and receiver

MEASURE PHASE WITHOUT RETURN PATH — FIG. 9

Phase characteristics of tape recorders, TV transmission networks, etc., may be measured with Type 524A3 although only a single path is available. In Fig. 9a, the tape recorder has two channels, one for storing signal with frequency f and the other for storing signal with frequency twice the amount of the first one, namely 2f. If transition time of the TV network in Fig. 9b is required to be measured, the transmitter is modulated simultaneously with two signals, f and 2f. Two filters are used to separate the signals at the receiving end. Apply these two signals to Type 524A3 Digital Phase Meter with signal 2f to "E2 IN" and signal f to "E1 IN". Since Type 524A3 Digital Phase Meter always reads E1 lags E2, an expression for the phase angle θ can be derived by graphical analysis of the coincident circuit as follows: θ = (meter reading — 90°) x 2. Transition time in seconds can be found by dividing the phase angle with frequency in cps and 360.



(1) UNK. PHASE AT $f_1 = T \times 360 \times f_1 = 2n\pi + \theta_1$

(2) UNK. PHASE AT $f_2 = T \times 360 \times f_2 = 2n\pi + \theta_2$

(3) $$n = \frac{\theta_2 f_1 - \theta_1 f_2}{(f_2 - f_1) \times 360}$$

(4) UNK. PHASE AT $$f_1 = \frac{f_1}{f_2 - f_1}(\theta_2 - \theta_1)$$

Fig. 10 – Measure phase angle over 360 degrees.

MEASURE PHASE OVER 360 DEGREES — FIG. 10

For measuring the electrical length of telephone cable or transmission networks, phase reading over 360 degrees is generally required. In Fig. 10, set the oscillator at frequency f1, obtain the phase reading on Type 524A3 as θ1. Let the total phase shift of the unknown be expressed in delay time T, such as: (1) Unknown phase at f1 = T x 360 x f1 = $2n\pi$ + θ1, where n is the number of complete periods delayed by the unknown from input to output. Now change the frequency to f2, which is chosen to be slightly higher than f1. We obtain a second expression: (2) Unknown phase at f2 = T x 360 x f2 = $2n\pi$ + θ2. Both T and n can be found by solving equation (1) and (2). The total phase shift is 360 x f1 x T at frequency f1 as expressed by Eq. (4) at left.

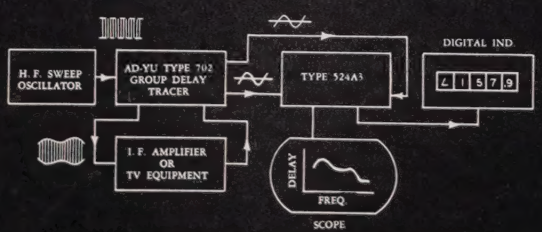


Fig. 11 – Plot envelope delay curve at RF and IF frequencies.

PLOT ENVELOPE DELAY CURVE — FIG. 11

Constant delay for all frequency components is important for faithful reproduction of input signals in TV equipment, radar IF amplifiers, transmission networks, etc. The arrangement of Fig. 11 can be used to plot envelope delay characteristics of an unknown network from 3 mc up to microwave frequencies. The signal from the sweep oscillator is amplitude modulated by the local oscillator of Type 702 Group Delay Curve Tracer at 100 kc (or lower frequency). The output from the unknown is demodulated and converted back to 100 kc before applying to Type 524A3 Digital Phase Meter. The analog output from Type 524A3 Digital Phase Meter is proportional to the phase delay between the local oscillator and the envelope of the output signal from the unknown. Therefore, the oscilloscope plots the envelope delay curve of the unknown with respect to the frequency of the sweep oscillator. Type 702 Group Delay Curve Tracer provides three delay ranges: 10, 20, or 40 microseconds. The digital d.c. meter is used to read small delay difference in the critical region, 0.03 milliseconds per digit with a 4-digit indicator.

INSTRUCTION MANUAL

FOR

TYPE 524A3 HIGH PRECISION

DIGITAL PHASE COMPUTER

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CIRCUIT DESCRIPTION

Fig. 1 (in the circuit diagram section) shows the circuit diagram of the Phase Computer chassis. Tubes V1 to V3 are connected as a three-stage cathode-coupled limiter for the E1 channel, and V5 to V7 operate similarly for the E2 channel. Tubes V4 and V8 are used as Schmitt triggers. The output square waves from V4 and V8 are differentiated; the leading edges become positive pulses while the trailing edges become negative pulses. Coincidence detection circuitry of the Phase Detector utilizes these pulses, yielding an output which is integrated and is fed to the digital voltmeter; this reads 360 degrees for -3.6 volts d.c. signal from the output of the Phase Computer chassis, calibration being accomplished by potentiometers R9 and R10.

When the "STAGE" selector located on top of the chassis is set at V1 to V8, the meter on top of the chassis indicates the plate current of the corresponding stages, V1, V2, V3, V4, V5, V6, V7 and V8, depending upon the position of the switch. The bias voltage of each stage can be so adjusted that its square wave output is symmetrical as long as the input signals are never large enough to cause the tube to draw grid current.

Fig. 2 shows a circuit diagram of the power supplies, which produce two regulated B+ voltages, 220 volts and 300 volts, as well as the heater voltages. The 6BL7 dual triode operates as the series regulator for both supplies while the 6BR8 is the control amplifier for both. The voltage reference is V11.

FUNCTIONAL CONTROLS, FRONT PANEL

1. "E1 IN" and "E2 IN", - uhf connectors which provide for connection of the input signals to the E1 and E2 channels.

2. "0° SET", - a 10k potentiometer (R9 in Fig. 1) which is used for adjusting the output to read 0.0 or 0.1 on the digital voltmeter while the FUNCTION selector is in its first position: "ADJ 0°".

3. "360° SET", - a 5K potentiometer (R10 in Fig. 1) which is used for adjusting the output to read 360.0 on the digital voltmeter when "E1 IN" is grounded, while the FUNCTION selector is at its second position: "ADJ 360°".

4. "FUNCTION" selector, - a 4-pole, 4-position switch which permits selection of one of two test positions ("ADJ 0°" or "ADJ 360°") or else one of two operating "OPR" positions. For normal operation of the Phase Computer the third "OPR NORM" position is utilized. If the digital voltmeter fluctuates because the signal frequency is below 100 cps, damping may be attained by using the fourth "OPR DAMP" position -- by means of which an RC damping network is added to the instrument output. In the "ADJ" position one of the output transistors of the phase detector is inactivated for the zero-set operation, and then the other for the 360° setting.

5. "ANALOG OUTPUT", - A front-panel BNC connector in parallel with the "DVM" rear-chassis connector. The output impedance is approximately 500K ohms.

6. "POWER" indicates the "ON" position of the toggle switch, with the pilot lamp indicating operation. An AGC-2 fuse is in the primary circuit, located on the rear of the chassis.

FUNCTIONAL CONTROLS, TOP-CHASSIS

1. "STAGE" selector, - 3-pole, 9-position switch (S2 in Fig. 1) used for connecting the meter located on the top rear to the output plate circuit of each of the limiters, V1 to V8, and for connecting the input grid lead of the preceding limiter to push-button switch S3. At "READ", the meter is not connected to the plate circuit of any stage, the Phase Computer being ready for normal use only in this condition.

2. "GR", - a push-button switch (S3 in Fig. 1) for connecting the grid lead of one of the limiters to ground in order to cut off the plate current of the preceding stage and temporarily to permit no signal feeding into the stage. This control is used only for adjusting the bias voltages, to produce symmetrical square wave outputs from each selected stage.

3. "R1" to "R8", - screw adjustment potentiometers, for bias adjustments of V1 to V8 stages respectively, as selected by the "STAGE" selector.

CONNECTORS, REAR-CHASSIS

1. "DVM OUTPUT", - BNC connector for connection to a digital voltmeter for direct indication of phase angle, 3.6 volts for 360°. The digital voltmeter should have input impedance of 10 megohms or more and the decimal point moved to the front of the digit for millivolt. Output impedance is 500K ohms.

2. "REC OUTPUT", - BNC connector for external recorder or other auxiliary output of the phase computer chassis which requires more rapid response then the output impedance. The output impedance is 200K ohms.

OPERATING INSTRUCTIONS

1. Plug the line cord into 115 volts (240 volts available on request), 50/60 cycles. Allow 30 minutes for warmup. Note that the ventilating fan at rear of the Phase Computer is turned on simultaneously.

2. Set the "FUNCTION" selector at "0° ADJ". The digital voltmeter reading should be zero (or 0.1°); if not, adjust the "0° SET" potentiometer for correct reading. If the digital voltmeter cannot settle down to any definite reading, it is probably due to the "0°" potentiometer being set below zero, plus the inability of the digital voltmeter to change its polarity from negative to positive automatically.

3. Set the "FUNCTION" selector at 360° "ADJ". The digital voltmeter reading should be 360.0° $\pm$0.1; if not, adjust the "360° SET" potentiometer. If this digital voltmeter has an internal impedance of less than 10 megohms, it may not be possible to obtain full scale reading of 360.0° because the output impedance is 500K approximately for the "DVM" output at the rear of the chassis; howver, such a DVM may possess filtering -- and so be able to use the "REC" output connector.

4. Turn the "FUNCTION" selector to "OPR, NORM". Apply the two signals whose phase difference is to be determined to "E1 IN" and "E_2 IN" and read the phase difference. If operating at or below 100 cps and the voltmeter readings are fluctuating, turn the "FUNCTION" selector to "OPR, DAMP".

5. To use an external recorder or other auxiliary output, connect the device to the "REC" output at the rear of the chassis. The input impedance of the recorder should be more than 1 megohm. Repeat the calibration procedure again to obtain full-scale deflection (as for No. 3, above.) Note that the actual voltage calibration, or scale, must vary with the loading; if both a recorder and the DVM are utilized, either may be adjusted to -3.6 volts for 360 degrees (using the "360° SET" potentiometer), but not both. Return the "FUNCTION" selector to "OPR" -- "NORM" or "DAMP" as for step 4.

BIAS ADJUSTMENT

Bias controls R1 to R8, on top of the chassis, should be adjusted if the meter reading varies with change of signal amplitudes. The procedure for adjusting the bias control R1, for limiter stage V1, consists of the following steps:

1. Apply a single signal approx. 5 kc, 5v with odd-harmonic content less than 0.2%, to both "E1 IN" and "E_2 IN". If the signal has more than 0.2% of harmonics disturbing waveform symmetry, the adjustments described below will not be accurate. A unit of Ad-Yu A103 filters should be used to clean the signal before applying to the instrument, for maximum accuracy -- since as little as 0.17 percent of odd-harmonics can produce 0.1 degrees of error.

2. Set the "STAGE" selector at top to 1. Take reading on the meter at the rear top of chassis.

3. Remove the input signal and short the input to ground. Take reading again; then adjust R1 until this meter reading equals that of step 2. Remove the short and re-apply the signal.

4. Repeat steps 2 and 3 several times to insure that the output plate current of V1 remains unchanged <u>when the input signal varies from zero to over 10v</u>. The precision of the instrument is critically dependent upon this adjustment.

The procedure for adjusting R2 for the second limiter stage, V2, is the same as just described with the following exceptions: In step 2, set the "STAGE" selector to 2; in step 3, depress the "GR" switch at top, instead of removing the input signal and grounding the input. Use a similar procedure to adjust R3. The procedure for adjusting R5 is similar to that of R1. The procedure for adjusting R6 and R7 is similar to that of R2 and R3. The order of adjustment must be from first to the second, to the third, to the fourth stage. This will insure that the input to the stage under adjustment (namely, the output of the previous stage) is a signal symmetrical with respect to the zero axis. Bias adjustment of R4 and R8 is different from those just described; the procedure for these trigger stages is as follows:

1. Set the "STAGE" selector at top of chassis to V4 (or V8.)
2. Set signal to zero.
3. Depress "GR" switch (near the "STAGE" selector.)
4. Adjust R4 (or R8) for minimum meter reading, holding "GR" down (closed.)
5. Still holding "GR" closed, turn R4 (or R8) gradually in the opposite direction until the indication on the chassis located on meter just jumps up. This condition insures that the triggering is just at the zero axis crossing.

NOTE: All adjustments should be made after the instrument is warmed up. Be sure that the ventilating fan is on during adjustments. Excessive heating may cause malfunction.

All d.c. potentials listed in the table below were measured with a vacuum tube voltmeter having 11 megohms input resistance. A voltmeter having a lower input resistance may register a different voltage, especially the d.c. potentials on the grids. Furthermore, the values may differ from one set to the other by ±10% or slightly more. Measurement of d.c. voltages and resistances often locates the source of the defect.

VOLTAGES TO GROUND*

TYPE	6085	6085	6DJ8	6DJ8
PIN	V1/V5	V2/V6	V3/V7	V4/V8
1	275	195	195	220
2*	-4.8	-3.4	-1.7	-2.5
3	98	53	128	128
6	290	220	220	220
7*	-5.4	-4	-2.6	-2.6
8	98	53	128	128

*Grid voltages (pins 2 and 7) were read from the cathodes (pin 3 or pin 8).

The inherent stability and reliable performance of this instrument is due, in part, to the use of highest quality components -- and to the careful selection and/or aging-into-stability of critical components including the amplifier tubes. If any one of the tubes, V1 through V8, is changed: Pre-age the tube for a few hours if possible; make frequent checks upon the bias adjustment of that particular tube, (with the "STAGE" selector on top of the chassis indicating the V-number of that tube); and perform the entire BIAS ADJUSTMENT procedure (described under this title, above) for all eight of these tubes before returning the Type 524A3 Phase Computer to service under normal maintenance conditions. If any servicing difficulty is encountered, be sure to contact the factory for advice as explained below; see FACTORY SERVICING AVAILABILITY.

For our customers who possess servicing capabilities, some of the more probable defects due to extended service are listed below:

1. Defect: - Phase reading changes with input signal amplitudes.

   Possible causes: - The bias voltage for one or more of the limiter stages has to be adjusted according to the described procedure. If the defect cannot be eliminated after careful adjustment of all stages, V1 to V8, it may be caused by one or more of the following conditions: (a) Voltage across the grid leak resistors (3 megohms) is not zero; positive voltage due to leakage of coupling condenser, or to a defective tube; negative voltage due to too high output from previous stage, or due to defective tubes of this stage or of this previous stage. (b) One or more of the limiter stages produce a round-top or round-botton square wave due to defective tube (cut-off characteristics not sharp enough); this can be found by observing the output "square wave" with an oscilloscope. (c) Input signal is not symmetrical with respect to the zero axis. (d) A by-pass capacitor has excessive leakage.

2. Defect: - Unstable in measuring small phase angle, and excessive error at high frequency.

   Cause: - Improper high frequency adjustment. Refer to section on High Frequency Adjustment. Perform indicated adjustments one step at a time until the originally noted error has been corrected.

3. Defect: - Digital voltmeter continues running or reading drifts.

   Possible causes: (a) Input signal has excessive distortion or insufficient amplitude. (b) The digital voltmeter is defective. (c) Leakage of coupling condenser between stages.

4. Defect: - "360°" potentiometer has insufficient range.

   Cause: - This is due to the impedance of the digital voltmeter being too low. The input impedance should be at least 10 megohms; most digital voltmeters have 100 megohms input impedance at balance. However, the DVM may be a special one, incorporating adequate internal filtering; if so, the lower impedance "OUTPUT" ("REC") may be utilized.

CHECKING INSTRUMENT ACCURACY

In checking the accuracy of precision phase instruments, very considerable care must be exercised in avoiding errors due to the use of inaccurate components, unsuitable "standards", and over-simplified "theory". Laboratory-standard decade-resistances containing "non-inductive windings" may be far less suitable than carbon-compound resistors except at very low frequencies. Therefore, practical testing methods (not dependent upon precise knowledge of R and C values in phase-shifting networks) have been devised, for use with ordinary molded resistors and low-leakage capacitors: mylar, polyethylene, mica, etc.

The Digital Phase Computer measures phase lag only (of input E_1, with respect to input E_2) and therefore possesses a 360-degree calibration. In Fig. 4, voltage vector E_1 lags E_2 by phase angle θ (measured clockwise from E_2.) Shifting the reference relationship of these (corresponding to interchange of the inputs to the Type 524A3 instrument) yields the vector relationship of Fig. 5, with E_1 lagging E_2 by $360-\theta$ degrees. (Because -- unlike other phase meters -- the instrument measures phase lag only, counter-clockwise angular measurements, of lead angle, are excluded from consideration.)

For any particular test frequency, the actual value of phase-lag θ depends upon the actual values of R and C -- which are seldom known to sufficient precision to compute a useful value of θ for checking a precision phase meter. However, note that the sum of the pair of readings (of Fig. 4 and 5) should be 360 degrees exactly, for any value of phase angle θ. Therefore, the interchange of the input leads to the 524A3 Phase Computer yields this practical test of instrument accuracy in ordinary use, which is not possible with other phase meters.

If the impedance of the RC circuit is very much lower than the input impedance of the phase meter, switching the positions of the resistor and capacitor as shown in Fig. 6 and 7 will yield the complementary phase relationships indicated -- the θ values being those of Fig. 4 and Fig. 5, assuming no change of components or of test frequency. Again, the sum of the readings for these last two cases should be exactly 360 degrees. Also: the phase angle reading for Fig. 7 minus that for Fig. 4 should equal 270 degrees; the same is true for the reading of Fig. 5 minus that of Fig. 6.

For example, if the test frequency is exactly 400 cps and C is exactly 0.1 uf, a value of 702 ohms for R will yield a θ of ten degrees (the Fig. 4 case.) Then, phase readings of 350 degrees, 80 degrees, and 280 degrees should appear for the other three cases, respectively. An oscillator voltage greater than 1.7 should be used, to keep the input voltage above 0.5 -- since the actual voltage input is oscillator output times the cosine of the phase angle θ, at one of the input channels to the 524A3.

The above methods of checking instrument accuracy may be used for frequencies up to 20 or 30 kilocycles, or even more, with increasing errors due to various capacitances. It is very important to note that this "theory" applies to sets of readings at particular test frequencies -- pure sine wave inputs being implied (without harmonic content.) While

the accuracy of the Type 524A3 instrument is not affected by waveform distortions which do not change the symmetry (location of the voltage cross-over at the midpoint of the time base, or period), the use of an inferior signal generator may introduce "errors" which are not due to the instrument itself -- but, instead, are characteristics predictable from theory. Thus, an apparent "error" of one degree could result from as little as 1.7 percent of unacceptable harmonics in the input signal.

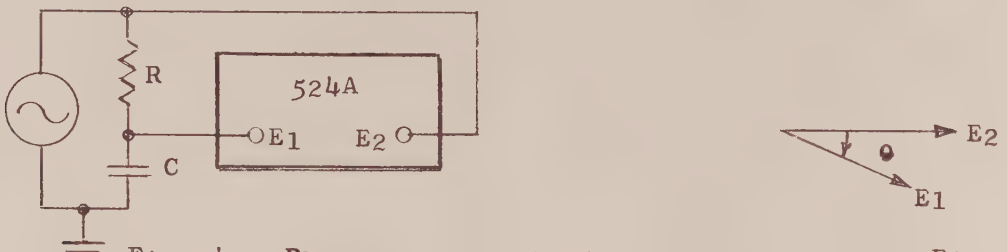


Fig. 4 - Phase reading is θ degrees, which is E1 lagging E2.

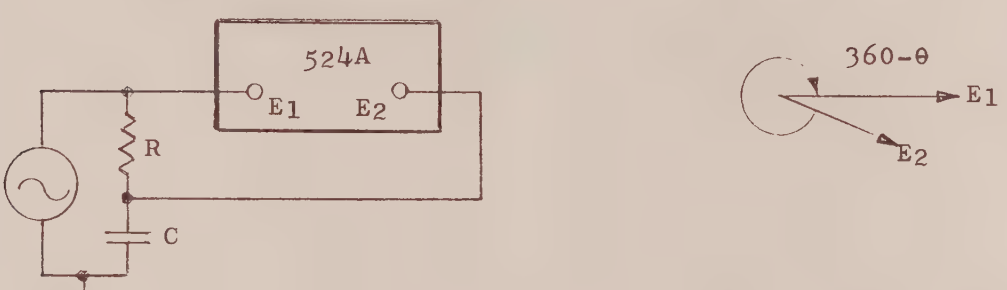


Fig. 5 - Since the 524A always reads E1 lagging E2; the phase reading is 360-θ degrees for this case of interchanged input leads.

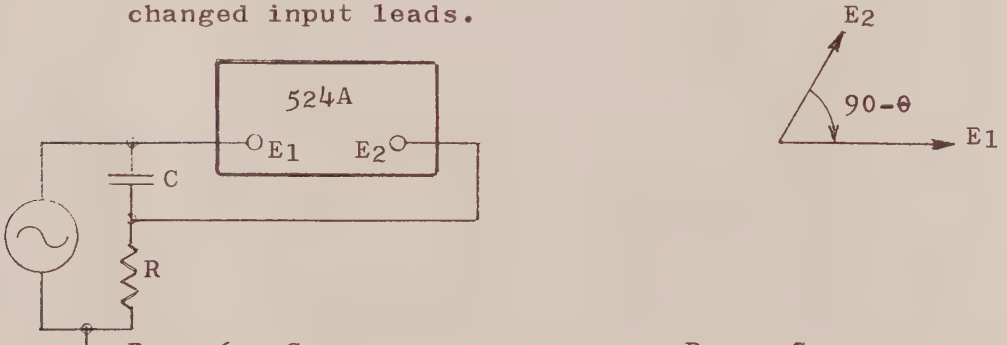
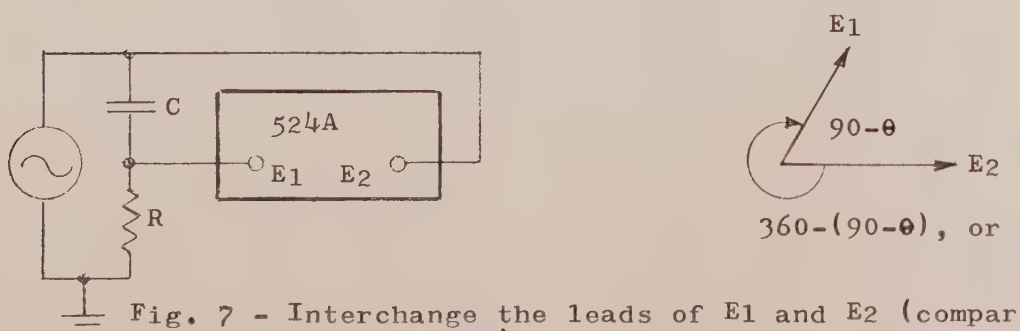


Fig. 6 - Since the positions of R and C are interchanged, the indicated phase angle becomes 90-θ.



360-(90-θ), or 270+θ

Fig. 7 - Interchange the leads of E1 and E2 (compared to the preceding case); the phase reading becomes 360 minus the reading of Fig. 6.

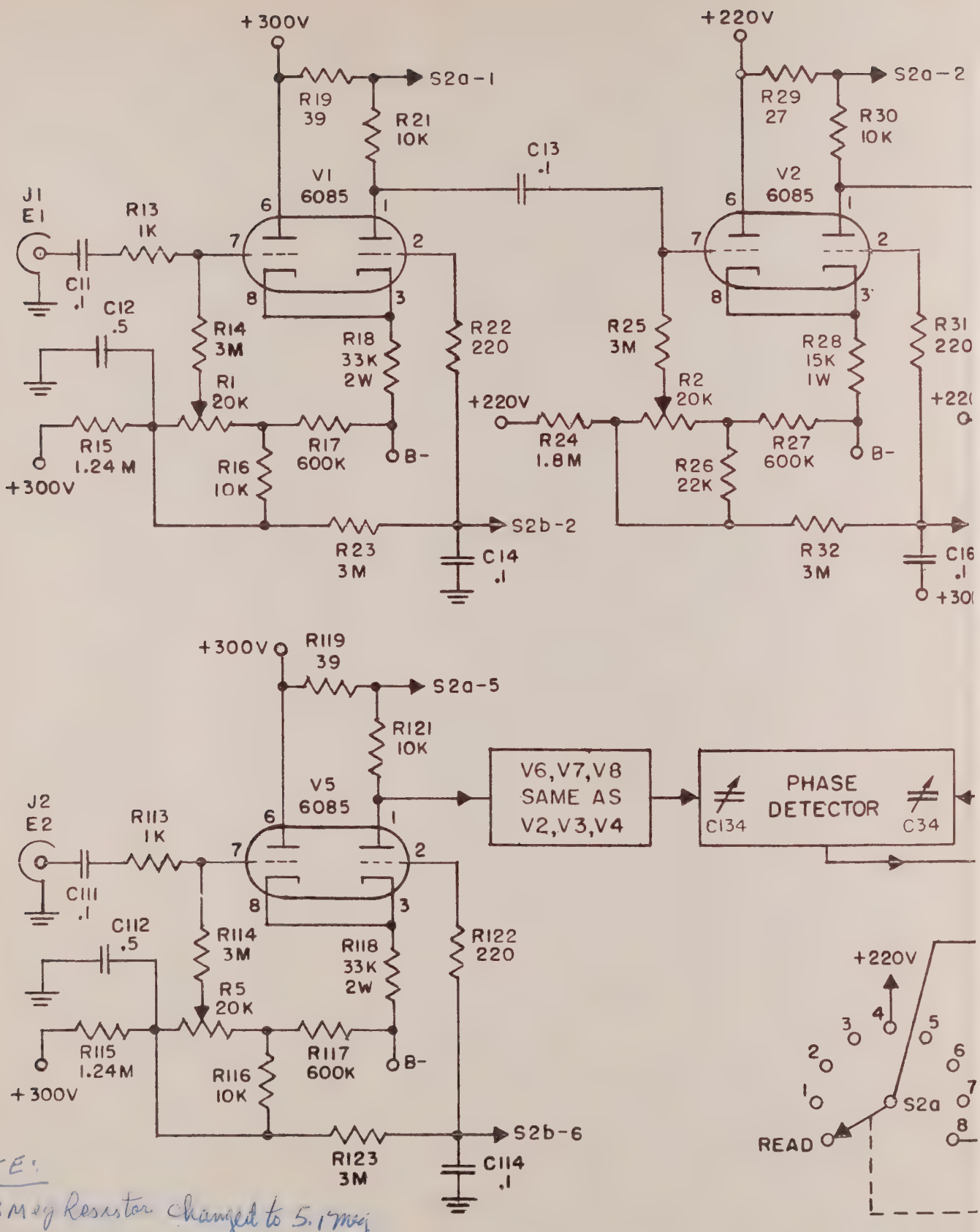
FACTORY SERVICING AVAILABILITY

I. Analysis By Mail; Avoiding Shipping:

All AD-YU instruments are designed to yield many years of satisfactory performance -- long after the standard guarantee period has expired. It is our policy to facilitate maintenance by our customers: by including maintenance information; by furnishing circuit diagrams and pertinent specifications upon critical components; and by continuous readiness to give engineering assistance by analyses of the particular troubles encountered by customers. We therefore invite correspondence regarding maintenance problems -- with the objectives of speeding servicing and of avoiding unnecessary shipments for factory repairs.

2. Procedure For Factory Servicing:

Specific instructions for shipping instruments back to our factory, for servicing, should be obtained prior to packing -- to avoid damage, and to permit us to serve to the best of our ability.



NOTE:

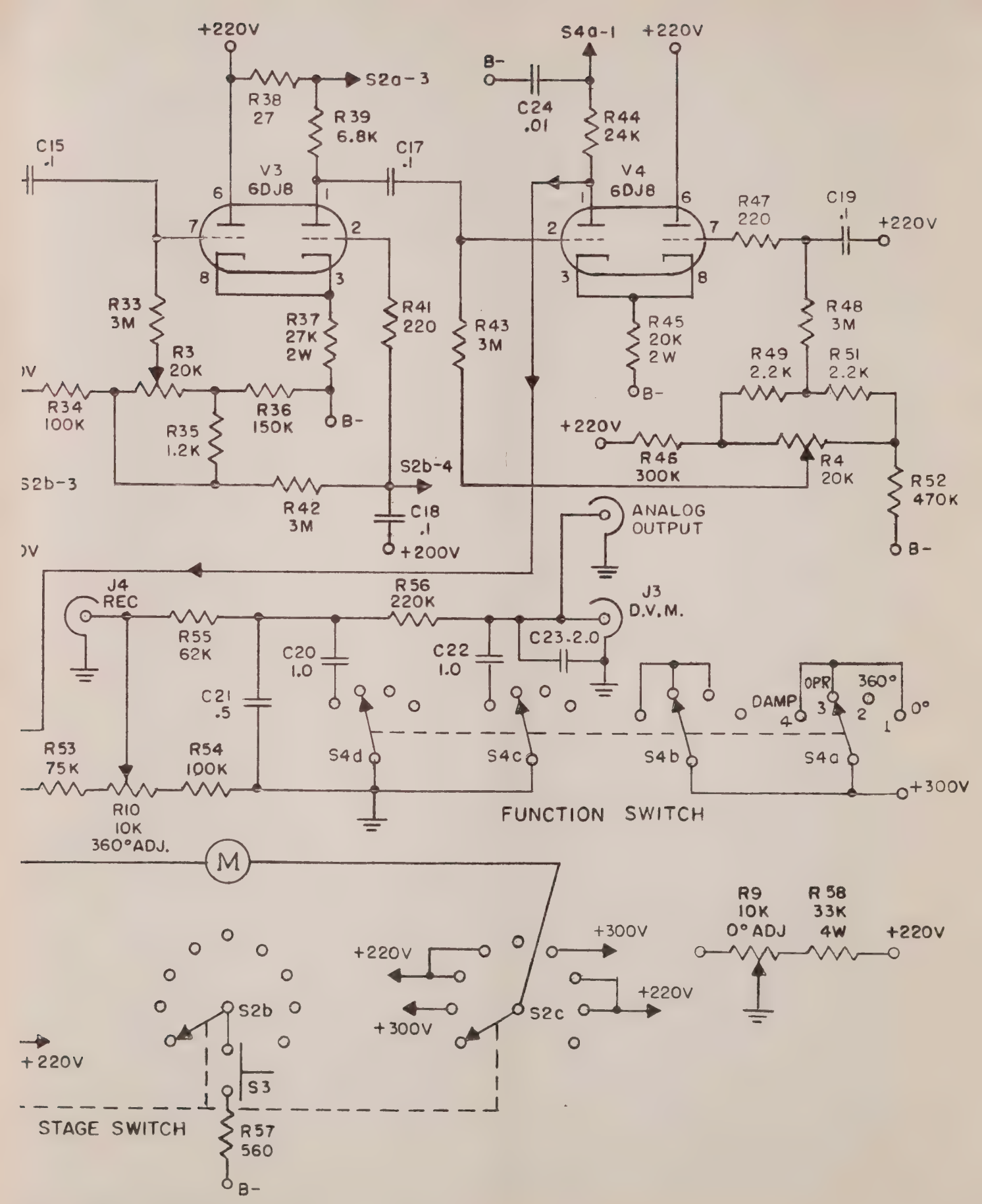
3 Meg Resistor changed to 5.1 Meg

NOTE.

DESIGNATION NO. FOR RESISTORS & CAPACITORS IN CHANNEL "E2" ARE 100 HIGHER THAN IN CHANNEL "E1".

5.19.66.
4.6.66.
8.19.65.

FIG. 1. PHASE COMPUTER SCHEMA



TIC TYPE 524A3.

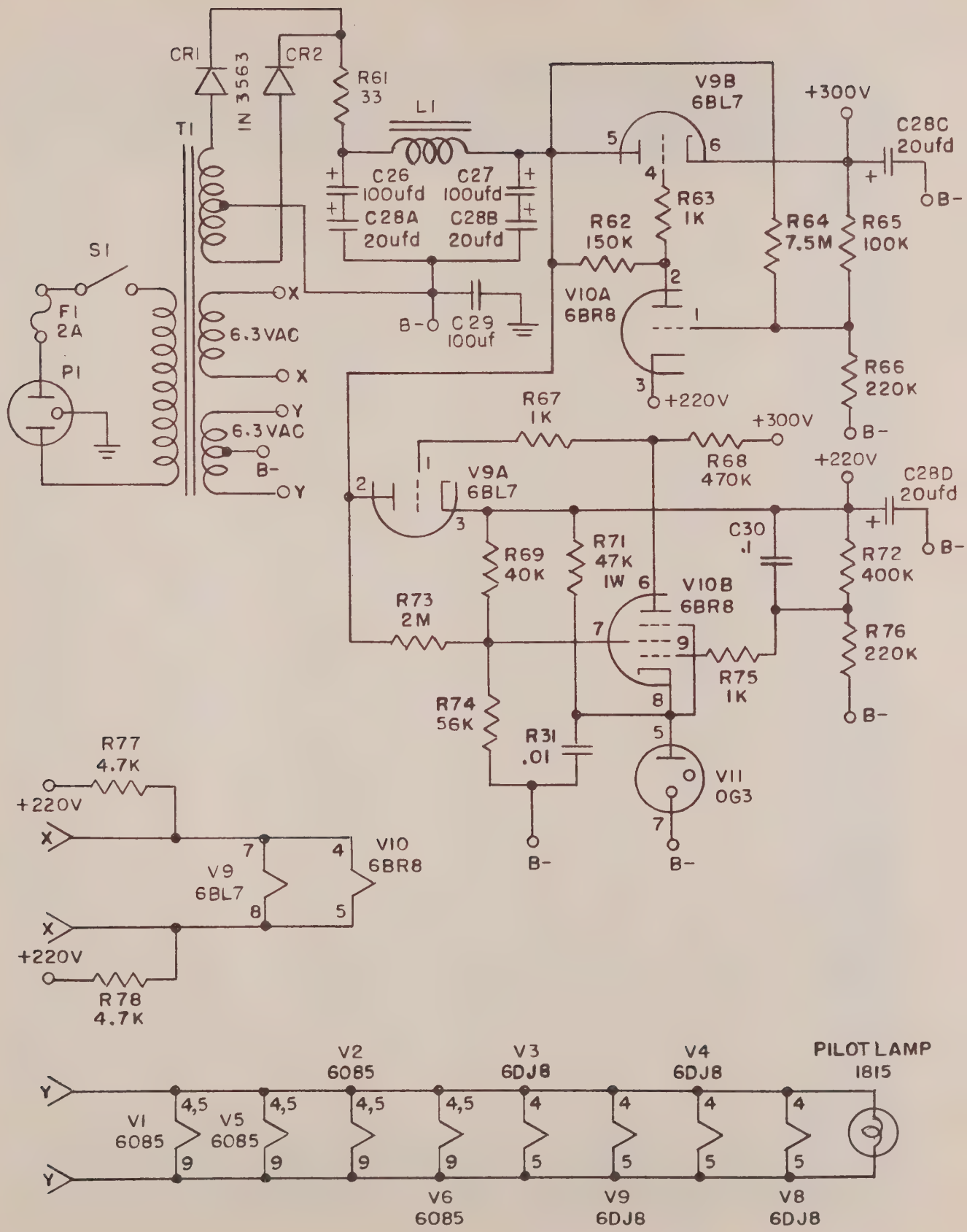


FIG. 2. POWER SUPPLY FOR 524A.

5.19.66.
8.25.65.

INSPECTION AND TEST

CERTIFICATION

Date 4/3/67

We certify that AD-YU Type No. 524A3L Serial No. A548P complies to the requirements of your Purchase Order No. _____ and meets all specifications for electrical performance and mechanical construction set forth by AD-YU ELECTRONICS, INC. All test equipment used to calibrate and check the specifications of this instrument is traceable, where applicable, to the National Bureau of Standards.

TEST TECHNICIAN CHIEF SUPERVISOR QUALITY CONTROL MANAGER

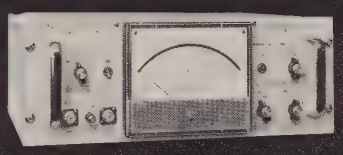
AD-YU ELECTRONICS, INC., 249-259 Terhune Avenue, Passaic, New Jersey

ADYU ELECTRONICS, INC.

249-259 Terhune Avenue, Passaic, N. J.
Phone: (201) 472-5622 - 3 - 4 - 5
Cable: ADYU Passaic

PHASE METERS: Direct reading in degrees. Analog output available for plotting phase characteristic curve. Frequency range 1 cps up to 10 megacycles.

PRECISION PHASE METERS
Type 406 - 406H - 406L
Direct Reading In Degrees, 1 CPS to 500 KC



FEATURES • Meter reading independent of input signal amplitudes . . . Useful for automatic plotting of phase response curves . . . Excellent general purpose phase meter.

Specifications

FREQUENCY RESPONSE: Type 406—8 cps to 100 kc; Type 406H—8 cps to 500 kc; Type 406L—1 cps to 100 kc.

PHASE RANGE: Direct reading in degrees with 8 ranges: 0-12°, 0-36°, 0-90°, 0-180°; panel switch converts ranges to 180-192°, 180-216°, 180-270°; 180-360°.

ACCURACY: ¼° relative, ±0.3° or ±2% absolute.

INPUT VOLTAGE: Type 406 and 406L—0.05v to 90v rms; Type 406H—2v to 50v rms.

INPUT IMPEDANCE: Type 406 and 406H—3 megohms shunted by 20 μμf; Type 406L, 6.8 megohms shunted by 20 μμf.

VECTORLYZERS
Type 202 - 202A - 203
Measures A Small Fraction of 1° With ±0.004° Accuracy

FEATURES • Accuracy ±0.004° or ±2% . . . Specially for small phase angle in the vicinity of 0°, 90°, 180° and 270° . . . Lead and lag identification provided.

Specifications

FREQUENCY RANGE: 25 cps to 40 kc for Type 202 and 202A; 50 cps to 20 kc for Type 203.

PHASE RANGE: 0-1, 0-2, 0-4, 0-10, 0-20, 0-180 degrees. A panel switch is provided for 180° phase shift for six additional ranges. Type 203 has 0-0.1, 0-0.2 degree-ranges.

ACCURACY: ±2% full scale for voltage measurement; ±0.02° (±0.004° for Type 203) or 2% for phase measurement.

INPUT IMPEDANCE: 20μμf shunted with 1 megohm.

DIGITAL PHASE METER
Type 524A3
±0.05° Accuracy, 5 CPS to 500 KC

FEATURES • No amplitude adjustment, no frequency adjustment . . . 0.1° resolution . . . Digital or analog output for programmable systems . . . Continuous coverage from 5 cps to 500 kc . . . Phase angle in degrees directly represented in four digits.

Specifications

FREQUENCY RESPONSE: 5 cps to 500 kc.

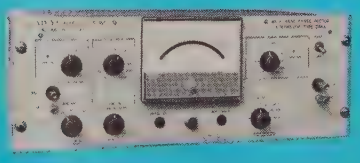
ACCURACY: ±0.05° relative, ±0.1° absolute up to 40 kc, slightly higher above 40 kc.

PHASE RANGE: 0 to 360.0° displayed in four digits without range switching.

INPUT VOLTAGE: 0.3 volt up to 50 volts.

INPUT SIGNAL RATIO: No adjustment from 10-to-1 to 1-to-100.

WIDE-BAND PHASE VECTOR VOLTMETER
Type 248A
Continuous Coverage From 40 CPS to 20 KC



FEATURES • Direct reading of total, fundamental, in-phase, quadrature components and phase angle in degrees . . . Reads a small fraction of 1° deviation from 0°, 90° 180° or 270° on panel meter with 0° or 90° center and ±10° full scale.

Specifications

FREQUENCY RANGE: Continuous coverage from 40 cps to 20 kc.

ACCURACY: ±¼° or ±1% relative; ±1° or ±2% absolute.

VOLTAGE RANGE: 0.001 up to 100 volts in 11 ranges with ±2% accuracy.

NULLING SENSITIVITY: Less than 2 microvolts.

INPUT IMPEDANCE: 1 megohm shunted with 25 μμf for unknown channel; 100K ohms shunted with 25 μμf for reference channel.

VIDEO AND RF PHASE METER
Type 422A
Direct Reading In Degrees From 20 CPS to 10 MC

FEATURES • No phase adjustment . . . No amplitude adjustment from 0.3 volt to 20 volts . . . Plots phase characteristic curve with swept frequency from 20 cps to 10 mc.

Specifications

FREQUENCY RESPONSE: 20 cps to 10 mc, useful above 10 mc and below 20 cps with relaxed accuracy.

PHASE RANGE: Zero to +180° or zero to −180° on 6.5" mirror scale.

ACCURACY: ¼° relative; ±1° or ±2% absolute plus 0.1° per megacycle or 0.1% of the reading.

WAVEFORM DISTORTION: Phase angle reading unaffected by harmonics which are 0° or 180° with the fundamental components.

INPUT IMPEDANCE: 1 megohm shunted with 30 μμf, each channel.

TRANSISTORIZED QUADRATURE PHASE METER
Type 609
Reads Small Phase Deviation From 90° or 270°

FEATURES • Scale centered at 90° (or 270°) . . . Useful for plotting phase characteristic curve with swept frequency . . . No amplitude adjustment, no frequency adjustment . . . Accuracy independent of spurious noise and harmonics.

Specifications

FREQUENCY RANGE: 20 cps to 50 kc.

ACCURACY: ±0.25° relative, ±1° or ±2% absolute.

PHASE RANGE: ±10° full scale (80-100°); ±30° full scale (60-120°); ±90° full scale (0-180°). All three ranges have center at 90° or 270°.

RESOLUTION: ±0.05° deviation from 90° detected on ±10° range; ±0.2° and ±0.5° on other two ranges.

INPUT VOLTAGE: 0.05 volt to 3 volts rms.

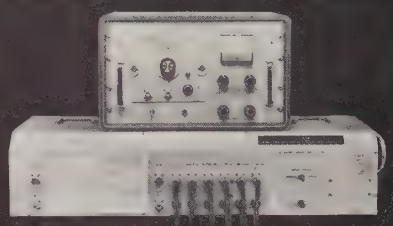
INPUT IMPEDANCE: 1 megohm shunted by 25 μμf.

World famous for phase measuring instruments from sub-audio to microwave frequencies. Delay lines, variable and fixed. Dynamic analysis equipment for vibration studies.

TIME AND PHASE DETECTORS: Suitable for cw or pulse-modulated signal. Accuracy ±0.05°, infinite resolution. Frequency range from 100 kc up to 18 gc.

PRECISION PICOSECOND PHASE DETECTORS

Type 205B1 - B4 - B5
15 MC To Over 1700 MC, Accuracy ±1% Or ±0.05°



FEATURES • Calibration traceable to National Bureau of Standards . . . Infinite resolution . . . Excellent for phase and time measurement of IF amplifiers, filters, transmission networks, klystrons, traveling wave tubes, etc.

Specifications

READABILITY: 10 ps/div. on main scale; 1 ps/div. on vernier scale.
TIME DELAY: Continuously variable from zero to 45 ns.

Type	Freq.	Preferred Use	Accuracy	Min. In
205B1	15- 400 mc	CW Signals	±0.05° or ±1%	50 mv
205B4	30-1700 mc	CW or Pulsed Signals	±0.05° or ±1%	100 mv
205B5	30-1700 mc	Pulsed Signals	±0.2° or ±1%	100 mv

PRECISION PHASE DETECTORS

Type 205A3 - 205A4
Measures Small Phase Angle From 100 KC To 15 MC

FEATURES • Measures phase angle down to 0.05° . . . Measures time delay as small as 8 x 10^{-10} second . . . Applicable for continuous, pulse-modulated or amplitude-modulated sine wave.

Specifications

FREQUENCY RANGE: 100 kc to 15 mc.
ACCURACY: Phase — ±0.25% or ±0.05° relative, ±1% absolute for phase measurement. Delay — ±1% for the step delay unit, ±2.5 nanoseconds for the continuously variable unit.
RESOLUTION TIME: 0.1 nanosecond or ±0.05°.
READABILITY: ¼ nanosecond.
MINIMUM INPUT SIGNAL: 0.08 volt rms (0.8 volt rms with low capacity probes).
INPUT IMPEDANCE: 1 megohm shunted with 12 μμf for both channels.

MICROWAVE PHASE AND TIME DETECTOR

Type 206A Series
1 GC to 8.2 GC, Accuracy ±1%

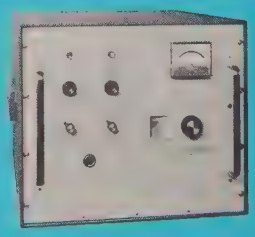
FEATURES • Suitable for pulsed sine wave with no limitation on duty cycle . . . Accuracy unaffected by amplitude fluctuation of both input signals . . . Capable of plotting phase curve . . . No errors due to tolerance of meter movement and circuit elements.

Specifications

FREQUENCY RESPONSE: 1 gc to 8.2 gc with three plug-in units at rear—Plug-in unit #1, 1 gc to 3.2 gc; plug-in unit #2, 3.2 gc to 7 gc; plug-in unit #3, 6 gc to 8.2 gc.
DELAY AND PHASE RANGE: 1000 ps total delay range, 360° phase range at 1000 mc.
RESOLUTION: Infinite.
READABILITY: 5 ps/div. on main scale, 1 ps/div. on vernier scale.

MICROWAVE PHASE AND TIME DETECTORS

Type 206B3 - 206B4
8.2 GC To Over 18 GC, Accuracy ±0.25°



FEATURES • Infinite resolution . . . Readability better than 0.1° with vernier scale . . . Capable of plotting phase vs. frequency curve . . . Extremely low input VSWR . . . No errors due to reflection caused by sampling diodes or mixer diodes.

Specifications

FREQUENCY RESPONSE: 8.2 gc to 12.4 gc (X-Band) for Type 206B3; 12.4 gc to 18 gc (KU-Band) for Type 206B4.
DELAY AND PHASE RANGE: The phase range is over 360° for the entire frequency range.
RESOLUTION: Infinite.
READABILITY: Less than 0.5° per division on the vernier scale at the highest operating frequency.
ACCURACY: ±0.1° or ±1% at any setting.

FREQUENCY CONVERTER

Type 306
Wide Frequency Response—750 KC Over 500 MC

FEATURES • Excellent sensitivity—response down to 50 millivolts . . . Direct reading of phase angle in degrees between two RF signals with a Type 406 Phase Meter.

Specifications

FREQUENCY RANGE: 750 kc to over 500 mc.
INPUT COAXIAL ATTENUATOR: 50 db in steps of 10 db.
EMITTER-FOLLOWER PROBE: Input impedance over 50,000 ohms shunted with 5 pf.
DYNAMIC RANGE: Over 70 db.
REQUIREMENT FOR LOCAL OSCILLATOR: Frequency 5 kc above or below RF signal.
AMPLIFICATION: Ratio of output audio signal to input RF signal is 40 db for both channels with local oscillator signal at 1 volt rms.

GROUP DELAY CURVE TRACERS

Type 701 - 702
Automatically Plots Group Delay Or Envelope Delay Curve

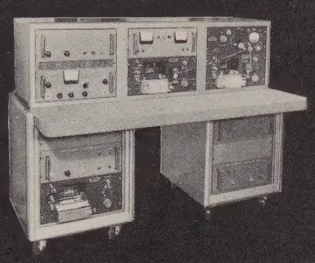
FEATURES • Magnifies delay characteristics in critical regions and plots overall delay distortion on one curve . . . Frequency swept over many decades from sub-audio to microwave frequencies . . . Measures amplitude response with 90 db dynamic range.

Specifications

CARRIER FREQUENCY: Type 701—250 cps to 600 kc; Type 702—100 kc to 10 mc.
DELAY RANGES: Type 701—0 to 12.5 ms and 0 to 25 ms full scale; Type 702—0 to 36 μs, and 0 to 1.80 μs full scale.
READABILITY: One part per 3600 of full scale delay range with a four-digit d.c. voltmeter.
STABILITY AND ACCURACY: Delay scales stabilized by fork oscillator (crystal oscillator for Type 702) within 0.001% per C°. Frequency accuracy within ±0.1%.

DYNAMIC ANALYZERS: Automatically plot phase angle, mechanical impedance, transfer function, power spectral density, time delay correlation, etc.

DYNAMIC ANALYSIS SYSTEM
Type 1010
Automatically Plots Mechanical Impedance, Mobility, Apparent Mass And Phase Angle



FEATURES • 80 db dynamic range . . . Phase accuracy ±¼° . . . Noise level up to 1000% without affecting accuracy . . . Filter bandwidth 2, 5, 10 or 50 cps changed by plug-in . . . Analog output available for digital readout of phase angle.

Specifications

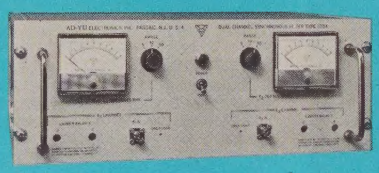
OPERATING FREQUENCY: 10 cps to 10 kc, useable down to 5 cps and up to 15 kc with relaxed accuracy.

ACCURACY: Phase — ±¼° relative or 1° absolute from 0 to 359.9°. Amplitude Ratio — ±½ db over 80 db dynamic range.

INPUT SIGNAL: Acceleration Channel—5 microvolts to 50 volts. Force Channel—500 microvolts to 50 volts.

FREQUENCY STABILITY: Drift in frequency of driver signal 0.1 cps per minute and 2 cps per hour after warmup.

DUAL-CHANNEL SYNCHRONOUS FILTER
Type 1034
60 DB Dynamic Range, Phase Matched Within 0.2° Over Entire Range



FEATURES • Isolates noise and harmonics over ten times signal level . . . Plug-in crystal filter facilitates change of bandwidth . . . Accurate meter indication . . . Fully transistorized with rugged construction for reliable operation.

Specifications

FREQUENCY RANGE: 3 cps to 10 kc for Type 1034A; 10 cps to 20 kc for Type 1034B.

ACCURACY: Phase—0.2°; Amplitude — ±0.5 db.

INPUT IMPEDANCE: 1 megohm shunted with 30 μμf.

SYNCHRONIZED SIGNAL: 2.5 volts rms sine wave.

VOLTAGE AMPLIFICATION: 60 ±0.5 db in both channels.

MAXIMUM OUTPUT: 50 volts rms both channels.

FILTER BANDWIDTH: 3 db at ±2 cps from center frequency. 5 cps, 15 cps, 50 cps or other bandwidth available.

SYNCHRONOUS CONVERTER
Type 1036
Designed To Be Used With Type 1034 Dual-Channel Synchronous Filter

FEATURES • Useful from 5 cps to 20 kc . . . Carrier frequency exactly matched with tracking filters and crystal controlled . . . Panel meter reads input or output amplitudes . . . Provides constant output for tracking filters up to 40 channels.

Specifications

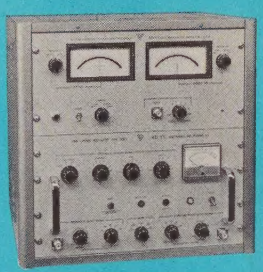
OUTPUT FREQUENCY RANGE: 3 cps to 10 kc above carrier for Type 1036A; 10 cps to 20 kc above carrier for Type 1036B.

OUTPUT IMPEDANCE: Less than 300 ohms, suitable for driving up to 40 channels of Type 1034 Synchronous Filter.

OUTPUT SIGNAL LEVEL: 2.5 volts rms.

CARRIER FREQUENCY OSCILLATOR: Crystal controlled at 20.5 kc for Type 1036A; 40.5 kc for Type 1036B.

TRANSFER FUNCTION ANALYZER
Type 308
Reads-In-Phase And Quadrature Components Simultaneously



FEATURES • Automatic and continuous plotting of transfer function when used in conjunction with X-Y recorder . . . Center zero gives direct identification of vector quadrature . . . Accuracy independent of spurious noise and harmonics.

Specifications

FREQUENCY RANGE: 0.1 cps to 10 kc, resolver unit extends up to 20 kc.

INPUT IMPEDANCE: 1 megohm shunted with 20 pf.

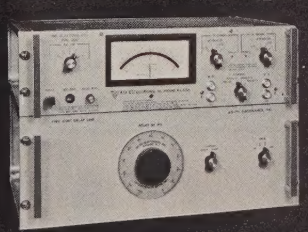
INPUT SIGNAL WAVEFORM: Accepts continuous sine wave or modulated carrier, or combination of both.

FULL SCALE SENSITIVITY: Eight full scale ranges—0.03, 0.1, 0.3, 1, 3, 10, 30 and 100 volts rms.

ACCURACY: ±2% of full scale at any range.

STABILITY: 0.2% after warm-up.

TIME DELAY CORRELATOR
Type 1050
Produces True And Accurate Time Correlation From 3 CPS To 200 KC



FEATURES • No false output due to random spikes . . . No error due to saturation . . . Zero response time . . . Completely transistorized . . . Equipped with continuously variable LC delay line.

Specifications

DYNAMIC RANGE: 100 db with panel attenuators 70 db without adjusting attenuators.

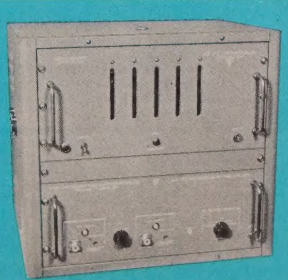
PANEL ATTENUATOR: 0.1 to $\sqrt{10}$ in 10 db steps for both channels.

FREQUENCY RANGE: 3 cps to 200 kc, upper limit modified by the selection of continuously variable delay line.

ANALOG OUTPUT AMPLITUDE: 0.1 volt positive or negative single-ended in respect to ground for full scale deflection.

DELAY LINE: Continuously variable with motor or manual drive from zero to 180 milliseconds in six models.

ULTRA-LOW FREQUENCY PHASE ANGLE AND FREQUENCY COUNTER
Type 1002
Useful For Measuring Phase And Frequency Down To 0.0001 CPS



FEATURES • Revolutionary new gating circuit with interlocking arrangement . . . One period of signal frequency to measure phase angle between two voltages . . . No amplitude adjustment from 2 volts to 120 volts rms . . . Resolution one part per 100,000.

Specifications

READOUT: 5 digits below 10 cps; 4 digits from 10 cps up to 100 cps; 3 digits from 100 cps to 1 kc.

ACCURACY: Phase — ±0.05°; Frequency — ±1 count.

TIME REQUIRED FOR READING: Equal to or less than 1/f (one period), where f is the signal frequency.

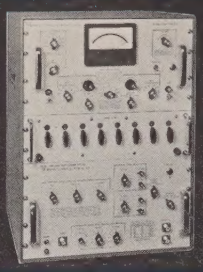
PHASE RANGE: 0 to 360.0°.

SIGNAL VOLTAGE: 2 to 120 volts without amplitude adjustment.

PHASE STANDARDS: Continuous coverage from 30 cps up to 10 kc. Accuracy ±0.015°. Traceable to NBS standards.

WIDE-BAND PRIMARY PHASE STANDARD

Type 209
Traceable To National Bureau Of Standards, Accuracy 0.015°



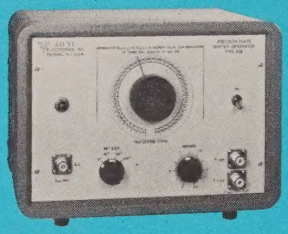
FEATURES • Continuous coverage from 50 cps to 10 kc . . . Self-checking by means of fundamental balanced bridge without the use of external standard . . . Phase shift can be set from 0° to 360° with 7-digit resolution.

Specifications

FREQUENCY RANGE: Continuous coverage from 50 cps to 10 kc.
PHASE RANGE: Can be set from 0° to 360° with 7-digit resolution.
RESOLUTION: 0.00001 degree.
ACCURACY: ±0.015°.
MAXIMUM INPUT: 70 volts rms.
INPUT SIGNAL REQUIREMENTS: Frequency Stability—0.15 x maximum tolerance of phase error. Waveform Distortion—0.2%. Source Impedance—600 ohms.

PRECISION PHASE SHIFTER GENERATOR

Type 208 - 208A
General Purpose Phase Generator/Shifter With 0.1° Accuracy



FEATURES • 3-dial setting gives 0.025° resolution . . . Continuous adjustment of phase angle from 0 to 360 degrees . . . Direct reading in degrees at any one frequency from 50 cps to 1500 cps.

Specifications

PHASE INDICATION: Direct reading on three dials—0 to 270° in 90° steps, 0 to 90° in 2° steps, continuously variable from 0 to 2.5°.
REPEATABILITY: 0.025° from 0 to 360°.
ACCURACY: 0.1° relative, 0.12° absolute.
BUILT-IN OSCILLATOR (208A ONLY): Tuning fork controlled with 0.001% stability and 0.05% frequency accuracy.
OUTPUT IMPEDANCE: 300 ohms shunting resistance and 2 μf series capacitance for d.c. blocking.

QUADRATURE PHASE STANDARD

Type A104
Wideband Operation From 40 CPS To 40 KC

FEATURES • Provides two output voltages with exactly 90° phase difference . . . Low output impedance . . . Wide range of signal amplitude . . . Simple to operate . . . No adjustment required.

Specifications

FREQUENCY RANGE: Continuous coverage from 40 cps to 40 kc.
ACCURACY: Phase error 0.05° from 40 cps to 10 kc, 0.1° from 10 kc to 40 kc.
MAXIMUM INPUT: 30 volts rms.
MAXIMUM OUTPUT: 20 volts rms.
OUTPUT MODE: Two modes selected with panel switch—0° between two outputs, 90° between two outputs.
OUTPUT IMPEDANCE: 300 ohms for both outputs.

ACCESSORIES

MINIATURE PRE-AMPLIFIERS Type A102 Series

Distortion less than 1%. Non-microphonic, no hum, completely shielded. Self powered, completely transistorized. Size—2⅞" x 1¾" x 1½" including batteries, except A102N.

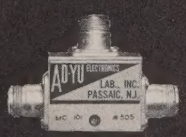
Type	A102	A102B	A102E	A102J	A102K	A102N
FREQ.	1cps-150kc	1cps-200kc	1cps-5mc	1cps-1mc	4cps-500kc	30cps-15mc
GAIN	100	1000	100	100	10,000	100
Z_{OUT}	100	5k	50	50	2k	8
NOISE	3 μv	2 μv	5 μv	4 μv	3 μv	10 μv

CONTINUOUSLY VARIABLE BANDPASS FILTERS Type A103 Series

Selects fundamental components from a distorted signal from 50 cps to 40 kc. 40 db attenuation for harmonics. Center frequency continuously adjustable in five groups: 1.5 to 1 range, 2 to 1 range, 3 to 1 range, 6 to 1 range and wideband range. Input impedance 100k and higher.

Type	Range	Type	Range	Type	Range
A103B4	100-150 cps	A103CA1	50-100 cps	A103D	50-150 cps
A103B7	600-900 cps	A103CA5	450-900 cps	A103D9	10-30 kc
A103B10	2-3 kc	A103CA7	1.6-3.2 kc	A103EA1	50-300 cps
A103B14	10-15kc	A103CA11	20-40 kc	A103EA7	2-12 kc

MATCHING DIVIDER Type MC-101



Matches one 50-ohm source to two 50-ohm loads from d.c. to 3 gc.

IMPEDANCE CONVERTER Type MC-102A-B

MC-102A matches 50 ohms to 73 ohms, MC-102B matches 50 ohms to 93 ohms from d.c. up to 2 gc.

LIMITING AMPLIFIER Type A102L

Converts sine wave into square wave with identical zero-crossing. 3 db bandwidth 1 cps to 600 kc. Maximum input 4 volts rms. Input impedance 100,000 ohms, output impedance 7000 ohms. 40 db amplification before clipping.

MINIATURE PRE-AMPLIFIER Type A1023 Series

Self-powered pre-amplifier with gain switch for 10, 20, 30 and 40 db. Convenient for laboratory use. 3 db bandwidth 1 cps to 1 mc. Distortion less than ¼%. Noise 3μv. Maximum output 4v rms. Battery life over 300 hours.

ULTRA-LOW NOISE PRE-AMPLIFIERS Type A1027 Series

Types A1027a and A1027b—miniature construction; Type A1027c—equipped with gain switch and front panel for laboratory convenience. Noise down to minus 150 db. Input impedance over 1000 megohms. Completely transistorized, non-microphonic.

Type	Frequency	Gain (db)	Z_{OUT}
A1027a	0.1cps-1.2mc	20 ±0.3	35 Ohms
A1027b	3cps-400kc	40 ±0.5	30 Ohms
A1027c	3cps-400kc	40 ±0.5	30 Ohms

MICROWAVE COMPONENTS

CT Series Coaxial Terminations: 50 ohms standard, VSWR 1.03 up to 1 gc, 1.1 up to 4 gc. **CA Series Coaxial Attenuators:** 3 to 60 db attenuation, 50 ohms standard; 0.1 to 60 db, 70 ohms on request.

Type MC-104 Microwave Coaxial Switch: MC-104A double-pole, double-throw; MC-104B single-pole, double-throw. Operate from d.c. to over 2 gc. Life expectancy—over 15000 operations minimum.

REPRESENTED BY:

PHASE METERS— Direct reading in degrees, no amplitude adjustment, no frequency adjustment, 1 cps to 10 mc Output for recorders.

Digital Phase Meter—Direct reading in 4 or 5 digits, accuracy ±0.03°. Analog output for recorders or programmable systems.

Vectorlyzer— Especially suitable for measuring small phase angle. Full scale sensitivity 0-1°, 0-2°, 0-4°, up to 360°.

H-F Phase and Mus Detectors—15 mc to 1700 mc, accuracy ±0.05° or ±1%. Suitable for CW or pulsed signals.

Microwave Phase Meters—1100 mc to 18 kmc. Suitable for CW or pulsed signals.

RF and Video Phase Meters—Direct reading in degrees. No frequency adjustment, 40 cps to 10 mc.

Wide-Band Phase Vector Voltmeter— Measures in-phase, quadrature, total components, and phase angle. 40 cps to 40 kc.

Transistorized Quadrature Phase Meter — Completely transistorized, 90° center, ±10°, ±30°, and ±90° full scale.

Automatic Analysis System—Automatic analyzing and plotting mechanical impedance, amplitude and phase, of any two signals. Accuracy ±1° phase, ±1/2 db amplitude. 140 db dynamic range.

Transistorized Pre-Amplifiers—Bandwidth 1 cps to 17 mc, 4 volts rms output.

Continuously Variable Bandpass Filters — Continuously tuned from 50 cps to 100 kc.

Wide-Band Time Delay Standards—Useful up to 1700 mc. Continuously adjustable.

Decade Delay Lines—Adjustable in four decades. Rise time 2%, up to 100 milliseconds.

Continuously Variable Delay Lines— Resolution less than 0.01 nanosecond. Rise time 10%.

Step Variable Delay Lines— Equal input and output impedance, 11 steps up to 120 steps.

Tapped and Fixed Delay Lines—Rise time 2%, 50 to 4000 ohms, meet MIL specifications. Delay from nanoseconds to milliseconds.

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